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SITE REQUIREMENTS OF YELLOW POPLAR

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An understanding of the site requirements of tree species and an appraisal of soil conditions for any given site are essential to successful forest management. Knowledge of soil and site conditions is especially necessary before forest planting is attempted, because even slight variations may make all the difference between success and failure.

This investigation of yellow poplar site requirements is a continuation of the soil profile-tree type study begun with black locust and black walnut and published as Station Note No. 31 (1).* It is preliminary in nature in that it is a part of a comprehensive study to be continued and extended to other species. This progress report may be modified in certain details as the study advances and will be incorporated eventually in a final report on the soil-tree type relationships of the region.

Plan of Study. The area covered in this investigation includes southeastern Ohio, Kentucky, Tennessee, southern Indiana, and southern Illinois. This region extends from the optimum range of the species to its western limit near the Mississippi River. Seventy-eight plots were taken at random wherever stands of yellow poplar could be found. Circular plots were established, usually 1/4 acre in size, but it sometimes was necessary to use 1/8-acre or 1/16-acre plots to take advantage of small tree groups. Plots were selected where severe fire and grazing had not occurred and scattered trees growing under pasture conditions were avoided. Most of the plots studied were even-aged, second-growth stands which had come in after lumbering operations; some had regenerated on old, abandoned fields. The plot ages varied from 12 to 61 years with 63 per cent of all plots between 25 and 45 years of age.

In the 1/4-acre plots 10 dominant trees, and in the 1/8 or 1/16-acre plots never less than 5, were measured as a basis for determining mean annual height growth which ranged from .64 to 4.0 feet according to site quality. The heights and diameters of the even-aged dominant trees in each plot were very uniform. Slope per cent, aspect, exposure, and other supplemental data such as natural tree association, natural regeneration, and condition of the stand were recorded. The soil on each plot was examined for depth of horizons, penetration of organic matter, color, texture, structure, reaction by the quinhydrone electrode, replaceable calcium, magnesium, phosphorus, and potassium. All chemical tests were made in the field by the use of a portable laboratory mounted on a 1/2-ton truck chassis.

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* Figures in parenthesis refer to literature cited.

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ANALYSIS AND DISCUSSION OF DATA ON SOIL PHYSICAL PROPERTIES

Drainage of the Site. Drainage of yellow poplar plots was estimated relatively in the field and classified as excessive, good, fair, poor, or very poor, according to the character of the soil profile, topography, geological strata, proximity of drainage systems, kind of ground cover, and similar factors. Drainage proved very significant in the analysis of the yellow poplar growth data. Only 9 of 78 plots were recorded as fair to poorly drained, and 3 of these had been planted. All others were recorded as well drained. The average annual height growth of these 9 poorly drained plots was 1.61 feet, - much less than the average for the moist but well-drained plots. Apparently yellow poplar will not grow successfully on poorly drained soil. Moreover, no yellow poplar stands were found on excessively drained sites and those on soils which tended to be dry were growing at a very slow rate.

Texture of the Soil. Of a total of 78 yellow poplar plots, there were 15 whose surface or A horizon were of finer texture than silt loam. They fell for the most part into the silty clay loam class. Several of them had a thin A_1 horizon with a texture of silt loam, but below this and above the true B the texture was silty clay loam. All plots whose texture was silty clay loam or heavier in the A horizon, were classed as heavy surface soils. The average annual height growth figure for this class was 2.24 feet. The fastest growing plot in the entire list had a silty clay surface, but its soil was residual from limestone and had a crumb structure. Another plot with a silty clay surface soil had an annual height growth of 3.2 feet. It cannot be said that, on the basis of texture in the surface soil, the heavier soils are inferior. They may or may not be, depending whether the structure is such as to counteract the effect of heavy texture on drainage and aeration or whether the heavy surface soil is also accompanied with a heavy subsoil.

As far as the subsoil is concerned excessive concentration of the fine textured fractions in the lower stratum is deleterious to successful growth of yellow poplar. One particular plot might be pointed out whose average annual height growth was only .64 foot. The subsoil in this plot is a tight drab clay (2). The site is dry because the possible water storage is diminished, and in time of drought the roots are cut off from ground water supply. Within a hundred feet of this plot is another of the same age whose annual height growth is 2.1 feet. The only apparent difference in the two is variation in subsoils. The fertility of the two surface soils is practically the same. A tight subsoil, particularly if it is near the surface, lessens water-holding capacity of the profile. Badly exposed sites with tight subsoils or excessively drained profiles constitute the most adverse conditions for growth of yellow poplar.

Tight subsoils are usually characteristic of mature soils. In general, immature soils in this region are found in steeply dissected terrain where the parent material is sandstone or shale - more often the former (6). The stages of soil maturity have significance to the forester in that they indicate different degrees of drainage and aeration. Speaking generally, a soil in a flat region which has developed an X or Y horizon (3) is likely to be inferior for the growing of yellow poplar to a soil in a rougher region

where the deep consolidated horizons have not formed. And in any given local area where examination shows the presence of a deeply weathered horizon, tree species which demand a well drained soil should be avoided.

Color of Subsoil. This study indicates a relationship between subsoil color and growth of yellow poplar in the Central States similar to that determined in the study of black locust and black walnut (1). By classifying plots as to subsoil color based on a scale varying from blue to reddish brown, it was demonstrated that sites which had subsoils tending in color toward the reddish brown end of the scale were capable of supporting much better growth of both locust and walnut than were those whose subsoils were at the drab or blue end of the scale. In this Brown Forest Soil Province* the brown and reddish brown soils are well oxidized and well drained, whereas if a soil has a high water table throughout a large part of the year, it will gradually become reduced and the oxides of iron will be blue instead of brown or red. All gradations occur from the waterlogged profile with a dense drab or blue subsoil to the friable, well-drained, reddish brown, immature profile whose B horizon has not developed.

In this study of yellow poplar distribution of soil color was found to be toward the reddish brown end of the scale. Out of 78 plots there were only six having gray, drab, or gray-mottled subsoils and three of these were in plantations. It is significant that the average annual height growth on these gray and mottled subsoils was only 1.47 feet. The first plot (.64 foot annual height growth) was in the Muskingum soil area, but was locally underlain with a tight, blue-drab clay. The second and third plots (2.1 ft. and 1.5 ft.) were within the area of Illinoian glaciation of southwestern Ohio and had mature profiles with gray-mottled subsoils and well developed X horizons (3). The fourth and fifth plots (1.8 ft. and 1.4 ft.) growing on the loess covered limestone residual soil of Hardin County, Illinois also had gray-mottled subsoil. The last in this group (1.4 ft.) represented a yellow poplar stand in western Tennessee growing on a terrace of ash-gray silty clay loam which had been covered with two feet of reddish brown sandy loam washed from Lexington soil above. It is significant to note that the plots were taken at random wherever poplar could be found and yet only three natural stands occurred on gray or mottled subsoils, and these were making an average annual height growth of only 1.5 feet. These growth rates are near the minimum recorded in this study for any part of the region.

Depth of Horizons. There was no apparent correlation between total depth of the A or surface soil horizon and annual growth of yellow poplar. The same was true of the B horizon depth. This latter is logical if we assume the important property of the B horizon is its ability to permit or hinder movement of water and air through the soil column. In this case the effectiveness of a B horizon would depend not on its mere thickness, but on its density. Obviously, a dense B horizon 2 inches thick might be more effective in retarding water or air movement than would a relatively loose B two feet thick. We should not expect to find correlation between soil horizon depth and growth unless we could, at the same time, appraise the density of the horizon with reasonable accuracy.

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*The Brown Forest Soil Province includes all of the region studied except a small area in western Tennessee and western Kentucky.

The failure to detect correlation between depth of the total A horizon and height growth of yellow poplar was coupled no doubt with the presence of so many immature soil profiles of the A C variety. In these cases, the division between the A and the C horizons is so uncertain that the differences as measured are not significant. There seems to be little doubt that a deep A horizon is superior for the growth of almost any of the upland hardwoods; it was so for black locust. If one had an array of data including all depths of A horizons, he would undoubtedly be able to trace a clear relationship. As for that matter, from the standpoint of aeration and water relationships, one would not be far wrong in calling an A C soil simply one with a very deep A horizon, in which case the effect of the A horizon would be unmistakable.

DISCUSSION OF ORGANIC MATTER

Depth of Organic Matter Penetration. Although no significant correlation could be determined between the total depth of the A or surface horizon, the depth to which the upper soil horizon was penetrated by incorporation of organic matter in this Brown Forest Soil Province (6) was closely related to the character of yellow poplar growth. This organic or A_1 horizon may be recognized by its darker color in contrast to that of the soil beneath. The depth of penetration ranged from a fraction of an inch to as much as 12 inches. It was deeper generally in cove than in slope or ridge soil and in north than in south slope soil.

Analysis of the data for 78 yellow poplar plots shows a substantially linear relationship between mean annual height growth and depth of the A_1 horizon. The range of A_1 horizon depths was from 1 to 12 inches and the height-age ratio, .64 foot to 4 feet. The correlation coefficient ($.53 \pm 05$) is highly significant. The standard error of estimate from the regression equation is .52 foot for the average annual height growth. This means that one may estimate probable growth rate of yellow poplar in the Brown Forest Soil Province from the regression equation and be accurate to within .52 foot per year. Parenthetically, it may be said that the range of accuracy is between 1 inch and 10 inches depth of organic matter incorporation. Not enough plots were available for depths less than 1 inch or above 10. The evidence is rather convincing that yellow poplar will not grow successfully on sites whose original A_1 horizon is less than 1 inch deep; and that any depth over 10 inches is either ineffective or indicative of swamp or prairie conditions to which yellow poplar is not indigenous.

The correlation of tree growth with depth of organic matter penetration naturally stimulates conjecture whether growth of yellow poplar is accelerated by the soil organic matter or whether the organic matter is merely incidental as a result of site conditions favorable to its accumulation as well as to tree growth. The amount of organic matter occurring in the soil is the result of an equilibrium between the amount produced and its rate of incorporation and decomposition. If yellow poplar would not reseed, become established, and thrive on any soil but that with a plentiful supply of organic matter, it might be concluded logically that growth of the species depended on it. However, yellow poplar often reproduces and grows

rapidly on old fields (7) whose surface organic matter has been removed by oxidation and erosion. Furthermore, as will be discussed later, yellow poplar is able to make maximum growth on moist sites whose supply of replaceable mineral elements is so low that it is extremely unlikely that fertility in the organic matter is responsible for the superior growth. Yellow poplar, once established on bare soil, in a comparatively short time produces enough litter to enrich the upper soil with organic matter in an amount commensurate with the initial productivity of the site. Numerous yellow poplar stands have been observed which, in the memory of the owners, have reseeded and developed well on abandoned fields. The organic matter penetration in these areas has been so rapid and to such a depth that the plow depth is now determined with difficulty. There is no doubt that the deposited organic matter influences growth rate in a cumulative manner as it grows in amount, but its presence is largely a result and not a cause.

ANALYSIS AND DISCUSSION OF CHEMICAL SOIL DATA

Calcium. Use of the Universal Soil Testing System (8) disclosed great variation in amounts of replaceable calcium in all soil horizons of the yellow poplar plots. The amount of replaceable calcium in the soil did not seem to influence growth in the least as far as the statistical analysis could disclose. That there is a connection between yellow poplar litter and calcium content cannot be denied after analyzing the data. The calcium is merely incidental, however. Yellow poplar is able to grow on acid soil, gather lime, and deposit it in the litter. This litter accumulating on the surface will in time build up the calcium content of the surface soil until in some cases more than a ton per acre may be recorded on soil whose subsurface fails to give even a test for replaceable calcium.

Table 1 shows several examples of this kind. Kentucky Plot No. 30 has 100 pounds in the surface 2 inches (calculated on a 7-inch acre basis) and Kentucky No. 31 has 1,000 pounds. The site indexes* are high for both plots: 97 and 118. Again, Tennessee Plot No. 14 has 1,500 pounds of available calcium with a growth rate of only 1.5 feet per year and a site index of only 74. Plots 30 and 31 have no detectable calcium below 2 inches, whereas Tennessee Plot 18 has calcium at the rate of 1,000 pounds per acre in the 4 to 6-inch horizon and 400 pounds in the subsoil, yet the plots with no calcium below 2 inches are able to support a superior growth of yellow poplar. Many more examples might be given to illustrate this fact; only a small part of the 78 plots is given here.

Concentration of calcium in the surface horizon occurred almost without exception on yellow poplar plots. This is illustrated in the average amounts of calcium found in the various horizons of 78 yellow poplar plots:

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*Site index (9) was calculated by the method of Osbourne and Schumacher and signifies height of stand at 50 years of age.

Horizon Depth	Pounds of Calcium Per Acre
0-2 inches	1,427 pounds
4-6 "	398 "
12-14 "	291 "

There is a much greater concentration of calcium than there is of magnesium in the surface horizon. As great a difference as 3,500 pounds per acre was recorded between the surface horizon and the soil immediately below it. Although large amounts of calcium in the surface soil are coincident with established poplar stands, the species will establish on acid soil and make good growth if other conditions are favorable.

Magnesium. No apparent correlation was found between amounts of available magnesium and rate of yellow poplar growth. An average of pounds per acre of available magnesium found in all plots in the 3 horizons is as follows:

Horizon Depth	Pounds of Magnesium Per Acre
0-2 inches	63 pounds
4-6 "	46 "
12-14 "	29 "

There is a slight trend in the amounts of available magnesium from the surface horizon downward which indicates moderate concentration of this element in the surface horizon. Magnesium is commonly associated chemically with calcium and it is interesting to note differences in the accumulation of these two elements.

Table 1 shows some of the variations which occur in magnesium content of soil under yellow poplar. For instance, Kentucky Plot No. 8, with an annual height growth of 3.4 feet per year and a site index of 89, has 100 pounds magnesium per acre in each of the 3 horizons, whereas Kentucky Plot No. 27, with an annual height growth of 4 feet and a site index of 105, has only 5 pounds of magnesium in the subsoil and a maximum of only 25 pounds in any horizon. Evidently, only very small amounts of magnesium are necessary for maximum growth of yellow poplar.

Phosphorus. It will be apparent from Table 1 that there seems to be no relationship between soluble phosphorus and growth of yellow poplar. Tennessee Plot No. 18 has 100 pounds phosphorus in the upper horizon with a height growth of 1.8 feet and a site index of 79, whereas Kentucky Plot No. 27 has very little in any horizon with a height growth of 4 feet per year and a site index of 105. The fact cannot be overlooked that in this case yellow poplar is able to grow at maximum rates where the amounts of phosphorus are exceedingly low. This indicates that the existing amount of this element is not limiting. If we can depend on the method, and it probably is about as accurate as any that has been devised, then the fertility requirements of yellow poplar are very low. Average pounds phosphorus per 7-inch acre are given below.

Horizon Depth	Phosphorus Pounds Per Acre
0-2 inch depth	66 pounds
4-6 " "	73 "
12-14 " "	65 "

Table 1

Growth and Soil Data From 12 of 78 Yellow Poplar Plots

Illustrating Contrasts in Growth Rates and Soil Differences

Plot No.	Average Annual Height Growth in Feet	Site Index	Age	Aspect	Depth of A_1 Horizon	CALCIUM Pounds* per Acre; Sampling Depth In Inches			MAGNESIUM Pounds* per Acre; Sampling Depth In Inches			PHOSPHORUS Pounds* per Acre; Sampling Depth In Inches			POTASSIUM Pounds* per Acre; Sampling Depth In Inches			REACTION - pH; Sampling Depth In Inches			County
						0-2	4-6	12-14	0-2	4-6	12-14	0-2	4-6	12-14	0-2	4-6	12-14	0-2	4-6	12-14	
Ky. 8	3.4	89	12	NE	8	500	400	400	100	100	100	75	100	75	100	100	75	5.8	6.1	5.8	Breathitt
" 16	1.6	70	42	N	2	0	0	0	2	0	5	25	0	5	0	50	0	6.5	6.0	5.5	Calloway
" 21	1.3	67	52	W	1	200		100	50	50	50	0	25	15	0	0	0	7.6	5.8	8.3	Nelson
" 27	4.0	105	19	N	8	3000	1000	200	25	25	5	0	25	10	150	175	0	8.1	6.9	7.9	Estill
" 28	2.6	85	27	W	3	1000	50	0	30	10	10	10	10	10	0	0	0	7.4	7.3	5.5	Estill
" 30	3.2	97	22	C	2	100	0	0	25	25	25	10	10	0	0	0	0	7.3	7.0	5.4	Wolfe
" 31	3.1	118	35	C	7	1000	0	0	25	25	10	10	10	0	0	0	0	7.3	6.4	5.1	Wolfe
Tenn. 13	1.8	82	45	E	2	1000	400	100	35	25	0	15	25	10	200	250	150	7.9	8.2	7.8	Madison
" 14	1.5	74	49	NE	2	1500	0	50	25	15	10	25	25	10	175	100	125	8.3	6.9	5.6	Henderson
" 15	1.5	71	46	W	1	1000	0	0	7	5	25	5	5	10	150	50	0	7.5	5.3	5.1	Dickson
" 18	1.8	79	43	NW	5	750	1000	400	25	25	10	100	10	5	175	250	50	8.0	7.7	6.1	Dickson
" 19	1.5	88	59	N	1	1000	100	0	25	25	25	10	5	5	250	150	175	8.3	7.1	6.3	Montgomery

*Calculated on the basis of 2,000,000 pounds per acre for the surface 7 inches.

An interesting fact may be observed in the apparent lack of concentration of phosphorus in the surface horizon. On the basis of averages of all plot data, phosphorus is the only element which fails to show surface concentration. Possibly this may be explained on the basis of phosphorus withdrawal into the tree from the leaves before abscission in the fall.

Potassium. What has been said regarding phosphorus may equally well apply to potassium. Apparently there is no relationship between recorded potassium content of the soil and the growth of yellow poplar. Indeed in some instances, as with phosphorus, maximum growth occurred on soil too low in potassium to give a test. This was repeatedly so in those soils, such as Muskingum, which are derived largely from sandstone. Average pounds potassium for all horizons are given below. Each figure represents the average of 78 plot determinations.

Horizon Depth	Potassium Pounds Per Acre
0-2 inches	130 pounds
4-6 "	72 "
12-14 "	40 "

Soil Reaction. The following table gives a short summary of the data on soil reaction, for all yellow poplar plots.

Horizon Depth	0-2 in.	4-6 in.	12-14 in.
Plots below pH 7	21%	71%	90%
Plots below pH 6.5	8%	47%	85%
Plots below pH 6.0	2%	31%	74%
Average reaction	7.35	6.45	5.74

If we consider pH 7 as neutrality, then the summary shows that only 21 per cent of all plots in the surface horizon fall below neutrality because of the concentration of calcium in the surface horizon. In the 4 to 6-inch horizon, however, 71 per cent of all plots fall below the neutral point, and in the 12 to 14-inch horizon, 90 per cent fall below pH 7. If we arbitrarily consider pH 6 as the point below which soil becomes decidedly acid, we see that in the surface soil only 2 per cent of the plots fall below that pH. If now we take the 12 to 14-inch horizon as the criterion of the normal condition of the soil independent of the influence of deposited organic matter, we see that a preponderant number of all soils examined are acid. Seventy-one per cent of all yellow poplar stands are on soil whose pH below 4 inches is acid. It is quite evident that at least a large portion of the roots of these trees are in acid soil. This fact, coupled with the observed reseeding of numerous poplar stands in old fields on acid soils where the organic matter is low and where in many cases the surface soil has been removed by erosion, is good evidence that the tree does not necessarily require a high pH or a large amount of calcium for its maximum growth. Indeed, it may be possible that acid soils are favorable to yellow poplar establishment.

Nitrogen. Owing to the fact that this report is preliminary in nature and that total nitrogen could not be determined in the field, a full report on this phase of fertility is not available at this time. However, as an illustration, two plots on which total nitrogen was determined gave an indication of its influence. Ohio Plot No. 4, age 19 years, with an average height

of 45 feet, was compared with Ohio Plot No. 5, adjacent, of the same age and with an average height of 10 feet. Total nitrogen in pounds per million pounds of soil was 1,290 and 1,200 pounds, respectively. These plots were within 200 feet of each other. Under the poor site was a tight clay subsoil; under the other, a deep, well drained profile.

The total pounds of nitrogen on the acre basis would, of course, be greater in the better site because of the greater depth of the A_1 horizon, but before attributing superior growth to nitrogen, one must answer questions regarding the reasons for the difference in depths of the A_1 horizon. In this case, there seems to be little doubt it was because of a tight clay subsoil under the poor site and not under the good site, thus making the former drier. Just as organic matter penetration is probably a function of soil moisture, so the total amount of nitrogen follows. The fact that yellow poplar will grow well on depleted soil of abandoned fields where organic matter and nitrogen supply are low indicates that large amounts of nitrogen are not necessary for maximum growth. It is likely that the nitrogen content of rainfall and that developed by nitrification on moist sites, even where organic matter content is low, supply sufficient nitrogen for good poplar growth. Nitrogen is necessary for tree growth as are all the other essential elements and no attempt to dismiss or even minimize its important role would be logical. However, in the light of the extreme importance of those properties of the soil profile which influence soil moisture supply, and in view of the very great influence of topography translated into aspect and exposure of the site, one must be cautious in attributing too much importance to any one element. Our previous study of black walnut and black locust failed to show that nitrogen was the limiting element of growth.

In the final report on soil profile-tree type relationship, the role of nitrogen will be given thorough consideration. There is great need for data on the minimum amounts of all the essential elements necessary for tree growth and this knowledge must be available before soil fertility can be used as a basis for predicting success of tree species on any site.

DISCUSSION OF TOPOGRAPHY, ASPECT, AND EXPOSURE

Exposure of Site. The term exposure is used in the true sense of the word as it pertains to the absence of protection from some force or influence and not alone in the sense of aspect. In this particular case it carries not only the aspect phase of the word, but also position of the stand in the topography that may contribute to or deprive it of the protection of nearby hills or adjacent timber stands. This connotation of exposure, then, is any influence which tends to make the site a dry one. A category of six measures of exposure were used as follows: sheltered cove, open cove, sheltered slope, open slope, flat terrain, and ridges.

Every forester has observed that yellow poplar grows better in a sheltered site than it does in an exposed one. The differences in rate of growth in the exposure classes substantiate by concrete evidence for the region this commonly observed condition. Average annual height growth values for plots falling in each of the categories are arranged in Table 2. By analysis of variance, there was no significant difference between exposure classes; the

population was essentially homogenous. This eliminates question as to the possibility of certain age classes being concentrated in any exposure category. The table shows that the best growth of yellow poplar occurs on sheltered sites, and the poorest growth on exposed sites.

By separating the plots into two classes on the basis of their geographic location in the eastern or western part of the region, it is shown that the annual height growth in the eastern is greater than in the western. The difference in average annual height growth in the two areas is .63 foot (2.46 against 1.83). This difference by method of variance is highly significant; the probability that it could be a chance happening is less than one in ten thousand. The east and west averages arranged by exposure classes are as follows:

	Cove Sheltered	Cove Open	Slope Sheltered	Slope Open	Flat Terrain	Ridge
East	2.64	2.76	2.58	1.99		1.40
West	2.60	2.30	1.82	1.86	1.65	1.60

While there is a distinct difference between growth in the two geographic regions, there is also a difference between growth in the exposure classes in each of the two regions. There is no factor more likely to be responsible for growth differences between exposure classes in a given region that that of moisture and it does not seem unreasonable to assume that the same factor is operative in creating the difference in growth between poplar in the eastern dissected region and the western flat to rolling region. Several decades of weather records show that there is more rainfall throughout the growing season in the eastern part of the region, whereas wind velocity is greater in the flat region to the West and this section is subjected to more severe desiccation. In the steeply dissected region of the Cumberland Plateau, fog and mist cling in the steep, narrow valley often until late morning, even in the summer time, and frequent summer showers are the normal occurrence. On the other hand, in the flat region of the West, the dew quickly dries on summer mornings and summer showers are not so frequent. There seems to be little doubt that soil moisture and atmospheric humidity are major factors in the growth rate of yellow poplar locally and regionally. Chapman (4) has well summarized these relations of forest distribution to topographic and climatic differences in this region.

Influence of Aspect. The aspect of a site in its influence on moisture is of great importance. This influence is clearly apparent in the changes of forest type or composition which occur on every forested area. In this particular region the north slopes generally are occupied by hardwoods with a leaning toward the mixed mesophytic. The south slopes and ridges are covered with variable mixtures from pure pine to oak-pine and often to the dry site oaks such as post, blackjack, scarlet, or scrub. The coves are commonly occupied by species such as walnut, ash, yellow poplar, gum, elm, etc., depending on the locality. There is little doubt that this difference in type is the expression of differences in soil moisture which in turn is

Table 2

Average Annual Height Growths of Yellow Poplar in Feet

78 Plots Grouped by Exposure Classes

	Sheltered Cove Feet	Open Cove Feet	Sheltered Slope Feet	Open Slope Feet	Flat Terrain Feet	Ridge Feet
	2.10	1.90	1.60	.64	1.40	1.30
	2.30	2.10	1.80	1.30	1.40	1.40
	2.30	2.20	1.90	1.40	1.50	1.50
	2.30	2.30	1.90	1.50	1.50	1.80
	2.40	2.40	1.90	1.80	1.50	
	2.60	2.40	2.00	1.80	1.50	
	3.10	2.50	2.10	1.95	1.80	
	4.00	2.60	2.20	2.10	1.90	
		2.60	2.20	2.10	2.00	
		2.80	2.20	2.20	2.00	
		3.10	2.30	2.40	2.10	
		3.20	2.30	2.70	2.15	
		3.40	2.40	2.80		
			2.50			
			2.50			
			2.60			
			2.60			
			2.60			
			2.70			
			2.70			
			2.70			
			2.80			
			2.90			
			3.00			
			3.00			
			3.20			
			3.40			
			3.50			
Average	2.63	2.57	2.48	1.89	1.73	1.50

controlled largely by precipitation, temperature, and evaporation. If this difference in aspect will cause a change in tree type, and it is readily apparent that it does, then it should exert a marked influence on the average annual height growth of yellow poplar.

Such is the case. By grouping the plots on north and east slopes and in bottoms and coves recognized as the more moist sites, and the plots on

south and west slopes and ridges as dry sites, there is disclosed a highly significant difference in growth rates. The average annual height growth for the moist site classification was 2.39 feet, whereas that for the dry sites was 1.78. The difference of .60 foot is highly significant. The probability that it could have been a chance happening was about 2 to 10,000. This significant difference in the sites of respective classification can be credited more logically to different rates of soil moisture evaporation than to any other individual variable. Soil analyses of moist and dry sites do not always disclose significant differences in amounts of available chemical elements, and often other soil properties are uniform enough at least to partially eliminate the soil variable from consideration. The A_1 horizon is deeper on moist sites; however, the amounts of soil moisture are greater and the surface soil temperatures are lower on sheltered sites than they are on exposed sites. It appears that the limiting factor of poplar growth is probably in most instances soil moisture.

SUMMARY

This is a progress report of one of a series of soil profile-tree type studies, begun with black walnut and black locust, which will be continued with similar studies of other species. The present investigation included 78 stands of yellow poplar in five Central States and involved determination of rates of growth and growth response to physical and chemical soil properties, aspect, exposure, and geographic location.

On the basis of careful analysis of the data, growth of these older stands of yellow poplar showed no correlation with amounts of available mineral elements in the soil. The fastest growing stands were found in sandstone and shale soils whose fertility level is probably the lowest in the region. These soils, because of the youthful character of their profiles and their position in steeply dissected terrain were generally moist, but well drained, and favored slower evaporation rates and lower soil surface temperatures.

Although no correlation was observed between amounts of mineral elements and growth of older stands of yellow poplar, fertilizer tests are now being made on seedlings and young trees to determine the influence on establishment and early growth. The very low requirement of trees for mineral elements indicates that a more sensitive chemical technique must be devised in order to find those amounts which are limiting to growth.

Depth of organic matter penetration in the surface soil horizon taken as the integration of meteorological and biological factors of site affords a valuable index to site quality evaluation for yellow poplar.

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